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Water, energy and the resource consumption puzzle: What about hydrogen?

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Abstract

If you google "Resource Consumption", then you will quickly find out that together with World Peace and Poverty this is one of the hottest topics on the global agenda. Interestingly, two of the most essential resources (potable water and clean air) are available basically free of any charge. No surprise then that these resources are becoming scarce. The market, defined as all actors on a given playing field, will not solve this effectively under the current rules of the game. It may solve it when it is too late, i.e. through means that no one will like.

Balancing consumption and solving the puzzle drive our policy makers, and their actions tilt the playing field. It is because of their actions in the early '90s that we are discussing hydrogen infrastructures at Hydrogen Conferences today. Players and policy makers alike observe the same events that constitute the resource consumption puzzle. If we understand the puzzle better, then we can predict what policies to expect, which ones will stand, and which will not. And also, where adding value to solving the puzzle will be most effective, most needed and easiest, where support will flow to, and where we can most efficiently de-risk our new technologies.

From the perspective of a venture capitalist, I will describe some of today's issues which every hydrogen start-up (every business to a larger or smaller extent) should address either directly or indirectly in their business plan:

- How does the technology relate to the Resource Consumption Puzzle?
- How effective is the business plan on the chosen playing field(s)?
- How robust is the proposition under the shale gale?
- What about the social sciences?

Finally, I will give some examples of high tech projects in developing economies being implemented to the benefit of all involved, robustly supported by public policy makers, and that are de-risking propositions effectively.

Keywords: hydrogen; public policy; venture capital; playing field; BRICS; developing countries; emerging economies; LNG; natural gas; paradigm; social sciences; nexus; energy vector; Conduit; Conduit Associates; resource efficiency; resource security

1. Introduction

Here's a question. Who is the natural owner of the hydrogen infrastructure? As matters stand, I do not think its the oil companies. They make (the bulk of) their money in Exploration and Production (E&P), while their downstream activities, where hydrogen would sit, simply provide the stability and channels their E&P activities need – or *used* to need. This should not be a surprise, but still many of you continue to dabble with chickens and eggs, and are blaming the oil and gas companies for the missing hydrogen infrastructure, while you know that, from their capital allocation perspective, their money is better spent upstream, and that there is a weak link, at best, between an oil and gas

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company's upstream activities and a hydrogen distribution network – although the natural gas revolution may change this. I will get back to this later. There is nothing wrong with letting of some steam, but it is better to leave the old paradigm behind, accept the playing field for what it is, and move on.

Natural ownership is an important question if you are looking for funding, or are prioritizing markets and products, and it is an important question if you are growing and selling companies at the cutting edge of hydrogen technology, as our venture capital firm, Conduit Ventures, does.

1.1 Conduit

Conduit was created by Shell and Mitsubishi, and started investing in hydrogen and fuel cell technologies in 2001, mainly in the Western world. Ten years later, Conduit has grown to include an active presence in Shanghai, and is putting Fund III together, as I am writing this text.

Conduit III will be a commercial consortium of large corporations from both developed and emerging economies, sovereign funds and financial investors. It will invest in technologies that address resource efficiency issues, which include water, energy, food and materials - globally, *including* in emerging markets.

This means that we have to prioritize technologies and make choices with the funds that we have at our disposal. To help do this, Conduit is supported by Conduit Associates, a formidable network of people that are active in various industries and governments, to influence and advise on roadmaps for integrating new technologies, and evaluate ideas and technologies on a first principles basis.

To take the right decisions, it is helpful to understand the bigger picture first. With this understanding you can formulate a strategy that should be robust, and will lead you to your objective.

1.2 The playing field

The playing field is not level – by design, it is not static – due to government policies, and there are multiple playing fields to choose from, to play the same game! Macro (and political) events unfold for all of us to observe. They influence policy makers, who do their best to interpret these events correctly, and adjust policies in an attempt to maximize prosperity for human kind – or their constituency – by trying to influence the behavior of companies and individuals, with the objective of, for instance, solving the resource consumption puzzle.

On this playing field companies and investors alike allocate their capital and prioritize their activities – looking at and interpreting the same events as the policy makers are seeing. We forecast (and influence) the actions of both our fellow-players, be they partners or competitors, and the policy makers. This is difficult enough, but occasionally, say, every four years, elections introduce even more uncertainty. And while we do all this, we should see and accept the playing fields as they are, not as they should be. Speculation makes bad business.

I will share with you some observations made by Conduit's Associates. One of them is that hydrogen as an energy vector (as an energy carrier) can already be applied commercially, *including in emerging economies*, which have fewer legacy systems (technology-wise) and where real growth is taking place.

Do you think government policies are more stable in the so-called developed countries, or in these emerging economies?

2. Understanding the Resource Consumption Puzzle

Lets start at a high level. A surging global population, and growth in the developing economies are putting pressure on the world's water, energy and food resources. Shell calls this the Nexus between water, food and energy [1]. Many large corporations are concentrating their innovation efforts at this cross-section of industries to find growth opportunities (and, geographically, in the high growth emerging economies).

Energy providers are among the largest industrial consumers of freshwater, even if their consumption is much smaller than the agricultural sector. At the same time, energy is required for the supply, purification, distribution and treatment of water and wastewater. In some Gulf countries the energy needed to desalinate water, accounts for around two-thirds of domestic oil use.

Quantifying these relationships helps policymakers have a clearer sense of how different energy pathways might affect precious water resources, while - with this quantification - industrial companies and investors will be able to make better strategic and investment decisions in a world of growing water scarcity.

The work in this field showed that freshwater consumption in the energy system will grow sharply [2]. That's partly because global energy demand will double in the first half of this century. It's also because the not-so-clever energy-crops, for biofuels, need a lot of freshwater. Halophytes and marine algae, salt water crops, have the future here. With plants relying heavily on solar energy, the region between the sub-tropics is where these technologies will be profitable first. This is also where most of the emerging economies are.

3. The New Abundance of Gas

The single most important development in the energy industry over the past five years is what has been called "the natural gas revolution", the "golden age of gas" or the "shale gale". Thanks to new technology and innovation, today we can affordably tap into vast fields of tight gas and shale gas embedded in rocks deep in the earth, recovering a resource that just a few years ago was considered out of reach.

Natural gas likely will play a far more significant role in meeting the energy challenge than we previously assumed. That last point is particularly significant in North America. President Obama recently said that the United States could become "the Saudi Arabia of natural gas". I don't think that this was an exaggeration. Add to that the increased oil production from the Gulf of Mexico, potentially huge deposits in Alaska and elsewhere in the Arctic, the growth in tight oil and heavy oil, including in oil sands, and a trend relating to a sense of urgency around renewables can be predicted. While the Western Hemisphere will still need to import oil, CERA estimates that the volume to import could fall by as much as half in this decade.

What impact will the new abundance of gas have on Hydrogen?

Liquefied Natural Gas (LNG) for transportation is an alternative to diesel, reducing emissions of sulfur oxides and particulates. In western Canada, LNG will be made available, this year, to fleet operators along the busy truck route from Calgary to Edmonton. Using the region's local resources to produce LNG, fleets on this route could see a reduction in greenhouse gas emissions of up to 20% on a well-to-wheels basis.

But every good thing comes at a price and some issues around the safety and environmental impact of developing these additional resources have generated increased public skepticism.

- The first is freshwater contamination by undisclosed chemicals used in the hydraulic fracturing fluids, due to poorly designed wells. You can watch some spectacular video clips on YouTube, which may have given shale gas an unfair image actually.
- The second is the excessive potable water use for hydraulic fracturing (or fracking);
- And lastly, the increase in greenhouse gas emissions due to methane leakage when producing shale gas.

With good regulation and tight monitoring these problems can be overcome, and the large oil and gas companies will almost certainly comply. "Small Oil", which is expected to take a significant share of the pie, may need a bit more attention.

The question to ask is: What is the world going to do with this additional fossil wealth? Is it going to replace "bad" fossil resources, such as coal, by good ones?

If not and it will simply add to supply and lower the prices of fossil fuels, then it will reduce the chances of developing renewable technologies. I believe that in Europe, with its targets and policies embedded as they are, "sustainable development" of renewables stand a better chance than in the United States. Strategies for companies developing technologies addressing resource efficiency should be robust in both scenarios, which can differ by region.

On top of that, as I mentioned earlier, individual playing fields are tilted by design, not just by the desire to achieve certain objectives supported by science-based facts, but also by politicians, who are driven by their constituencies with shorter term and more localized objectives, both geographically and socially. As a result, not all resources (such as fresh water and clean air) are priced correctly, from a global and longer-term perspective.

Therefore, on the current playing fields, hydrogen-as-a-fuel-*only* has a difficult time.

4. Clean or Green Hydrogen

Hydrogen must be clean or green, because a value proposition on efficiency *only* is, I believe, not compelling. For *clean* hydrogen – produced from natural gas – the CO_2 must be dealt with. A good use of CO_2 is enhanced oil recovery, where the CO_2 is injected in oil wells to increase their efficiency. It is unfortunate that today, perfectly sequestered and stored CO2 is released through CO_2 wells to do just this. Kinder Morgan provides more than 1.5 BCFD to the Permian Basin, Utah, and the Oklahoma Panhandle from two CO_2 domes, the McElmo Dome and Bravo Dome. The McElmo Dome is one of the largest known CO_2 supplies in the United States, containing more than 10 trillion cubic feet of CO_2 [3]. For policy makers and hydrogen supporters alike, a moratorium on CO_2 drilling (or an effective CO_2 tax) should seem a logical objective given today's support for Carbon Capture and Sequestration (CCS), as Hydrogen and CO_2 are two sides of the same coin.

Green hydrogen, produced from renewable sources via electricity should logically be a long way off, because in general it is more efficient to connect renewable sources of electricity *directly* to the users of electricity, and to not introduce inefficient energy-vector conversions (from electricity to hydrogen, and back).

However, where there *is* an excess of renewable electricity, such as in Iceland, or for instance because of a regional overbuilding of wind-power, such as felt in the North of Germany, the need to store energy will build the case for hydrogen as an energy-vector, as the development of technologies to directly store electricity on medium to large scales is not being anticipated with much optimism.

BEBA Energie's project in North Germany aims to convert their excess wind power in hydrogen and store it 800 meters under ground in existing salt caverns. Hydrogen storage in salt caverns is not new. I know of ICI having stored 95% pure hydrogen for industrial customers in caverns in Teeside UK, and Gaz de France has stored 50% pure town gas [4]. But in the BEBA project the driver is large-scale storage of excess energy, and therefore the use of hydrogen as an energy vector.

Thus green hydrogen will become available, logically flowing from reality. It will become available for a combination of applications in industry and for mobility. However, the underground storage of hydrogen will, in my view, attract as many social issues as the underground storage of CO2.

5. Social Factors and the Developing Economies

In Barendrecht, a city in The Netherlands, a project to store CO2 in a former natural gas reservoir was cancelled [5] because the inhabitants of the region did not want to live on top of a CO2 storage area.

Although technically the case was made, and the Health Safety and Environmental analysis, the HSE-case, was carefully prepared and presented, the stakeholders, and especially the inhabitants, were not sufficiently involved. Action groups and a NIMBY attitude scuttled the project. In the Netherlands too, perception is reality.

Again we are reminded that solutions of issues high on the global agenda are not only to be found in the technical sciences, but even more so in the social sciences.

In developing countries I expect that the growth of renewables, admittedly from a lower base, will continue much less encumbered. But which developing countries?

Everyone knows about the BRICS. An acronym coined by Goldman Sachs in 2001. With the possible exception of Russia, these countries have done very well over the past decade. Other banks have now created lists of their own based on three factors [6]. A stable sociopolitical environment is essential; institutions and the rule of law are necessary for growth. At the most basic level, legal institutions are needed to guarantee contracts in order to motivate people to invest. Another important factor in a country's success is human capital, with people educated at primary and secondary level: long-term growth can't be built on cheap labor. The third and final factor is basic infrastructure: electricity, roads and bridges, and ports.

The only country that was selected by all four institutions was Indonesia, Followed by Nigeria, Vietnam, Turkey, and Egypt, which were included in three of the four analyses. Other countries mentioned more than once include Bangladesh, Mexico, and the Philippines.

This does not mean that all these countries are appropriate focus areas to de-risk and commercialize new technologies, which are renewables and, especially, hydrogen related. Good decisions require evaluation along a thought-through decision framework, evaluating the needs and capacities of the countries involved, and the willingness to address issues around path dependence [7].

Let's have a quick look at some projects and activities taking place in China, Brazil, Africa, and the Middle East.

5.1 Shanghai

When I was working for Shell in Tokyo, it struck me how much easier it was to build the station in Shanghai, compared to Shell's hydrogen stations on the US East Coast. The discussions with the stakeholders around the Benning Road station in Washington delayed its opening for over a year.

The Hydrogen refueling station in Shanghai, located at the International Automotive City in Anting, dispenses compressed gaseous hydrogen for a fleet of fuel cell cars and buses that operated in the Shanghai region. The Shanghai government has already helped to deliver dozens of fuel cell vehicles operating in Shanghai, and this is planned to grow exponentially, including fuel cell buses sponsored by the Global Environmental Facility (GEF) through the United Nations Development Program.

Tongji University is responsible for the development and operation of the new hydrogen station, with Shell contributing technical advice and part of the funding. Importantly, the station also features an information center on the hydrogen economy.

5.2 Sao Paulo

In November 2010, the first Fuel Cell Bus in Brazil started operation for passenger transportation in São Paulo. This project has also been funded by the Global Environment Facility and the Brazilian Government. The Brazilian Fuel Cell Bus prototype is the first step of a broader market entry program in Brazil, which will continue with three additional busses. The program includes a hydrogen production and filling station consisting of an electrolyser (with 120 kg hydrogen/ day production capacity), a storage facility and a compressor with 350 bar filling capability

A consortium of Brazilian companies have built the bus and the station, working with international partners. In this way the objective of technology transfer from leading companies in fuel cell technology / to local partners in Brazil was realized.

5.3 Africa and the Middle East

On the other side of the spectrum, relying on private investors, and much less so on international institutions, hydrogen start-ups are bridging developed countries with emerging economies, simply because it is good business.

HelioCentris is an example with an effective approach. One of its offerings is stand-by power, replacing diesel gensets for, for instance, communication towers. Itself a product that is much more needed in developing economies than in developed ones. An other start-up company, such as Hydrexia, could supply the required hydrogen storage device. They offer a metal-hydride storage medium, mainly for stationary purposes.

HelioCentris is using a step-down approach. Instead of simultaneously implementing the hydrogen system and the energy manager, it starts with the energy manager to lock in the customer, and then upgrades to the hydrogen system.

And the approach works, because most customers feel much more comfortable with a gradual approach. First get to know the technology, the partner, and then develop the required capacities in a robust manner. The Emirates, Mozambique and Zimbabwe are among the countries where HelioCentris has activities.

5.4 South Africa

In a Press Release one month ago Ballard's business development director says:

"We were not even aware that South Africa was looking into this technology until we were approached by Anglo American to partner with them on certain projects in South Africa".

It is a telling comment – and therefore useful to make you aware too. South Africa is an important supplier of platinum, and they are now ready to jump from university programs under the HySA umbrella, "Hydrogen South Africa", to demonstration projects.

Together with Ballard, Anglo American showed off the first fuel-cell-powered underground locomotive. Anglo was also responsible for powering COP 17, with a 150 KW fuel cell in December 2011.

6. Summary

I have made some ten or twelve observations that may have been of interest to you. One of them was that it is good to remember where you come from, because it defines your actions and, importantly, your perception. Some three decades ago the argument centered on global warming and clean air. The argument remains correct, but it may be more useful to view hydrogen as one way to solve the resource consumption puzzle.

Get Real, on today's playing field. See and accept the playing field as it is, and create real value-propositions that address real markets. Only finance limited-time projects, or short-term goals with subsidies, but your business plan should be robust without any subsidies on your chosen playing field, today. And by all means, influence the policy makers to change the playing field, which in turn should increase the option value of your undertaking.

I do not think that the natural owner of the hydrogen infrastructure must be one of the established players or industries. I think that some of the new companies in the Hydrogen industry have a real chance in becoming the energy multinationals of the future. These future multinationals will have fewer legacy issues, but will not necessarily do everything differently from the established players. They should also look at the opportunities at the nexus of different industries, and at developing regions that, as they, do not have legacy issues in specific fields of technology, infrastructure, and structuring.

Regarding natural gas, I have seen some presentations at this 2012 WHEC conference where hydrogen's qualities are compared with "evil" diesel. I suggest that these presentations should be updated by adding comparisons with LNG and GtL, because the abundance of gas will change the near term future as we are accustomed to seeing it.

And finally, the social sciences, probably the most underestimated, and truly key enabling, or, disruptive factor impacting the de-risking and commercialization of new technologies. If you want to succeed in creating a thriving football activity and following:

It is not sufficient to build a big stadium.

It is not sufficient to attract a good team.

You have to get many fans.

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